DISCHARGE BASED EUV SOURCE FOR MASK INSPECTION

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Discharge Sources for Metrology

- discharge sources are already in commercial use for metrology applications, high maturity achieved
- high efficiency for the conversion of electrical energy into EUV light
- typical plasma geometry: several 100 µm in diameter, several mm in length
- optical system for the homogeneous illumination of 50µm field of view easy to implement

Source Concept

Fig. 1: Novel ILT gas discharge source for metrology

- technical base is the HCT source developed with Philips EUV used for ASML Alpha Demo Tool
- sources are already in use for: optics characterization, mirror lifetime studies, interference-lithography, x-ray microscopy etc.
- new system allows higher input power and pulse energy
- simplified and more compact source head design
- emission in the soft x-ray to extreme ultraviolet range
- increased electrode lifetime

Technical Data

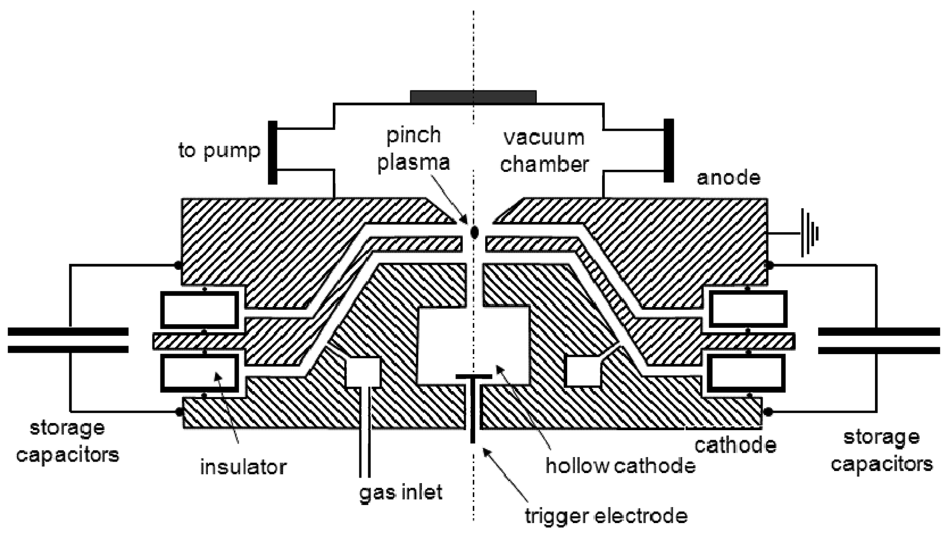
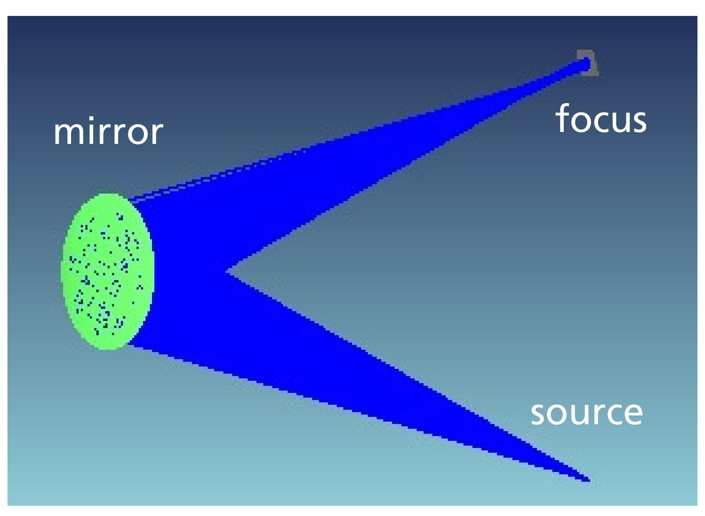
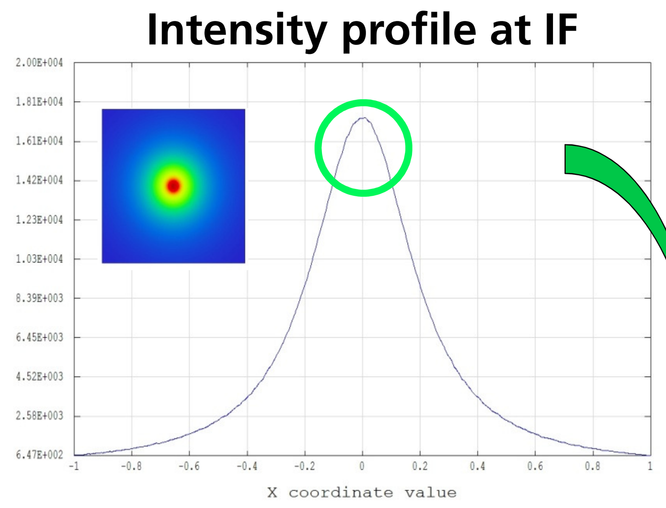


Fig. 2: Scheme of the electrode system

- max. input power: 25 kW
- max. pulse energy: 20 J
- emission at 13.5nm: > 50 W/(2πsr 2% b.w.)
- typical plasma length: 3-5 mm
- accessible collection angle: > 80°

Source-Collector-Module simulation





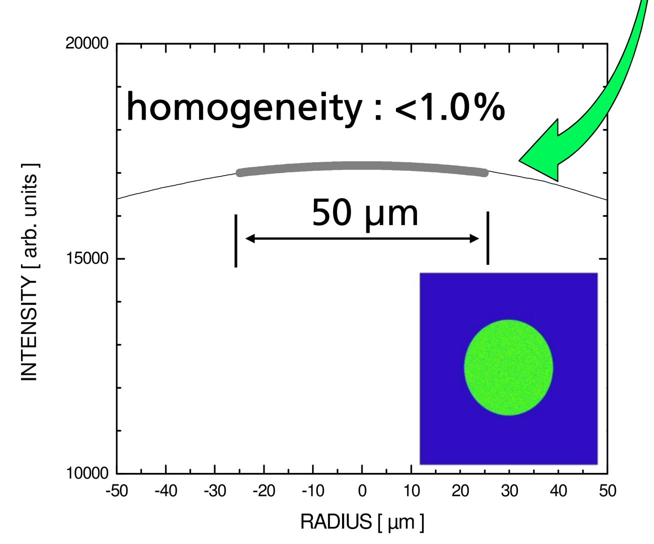


Fig. 3-5: Raytracing of SoCoMo with resulting intensity profile at the intermediate focus

- example for typical normal incidence source-collector-module ~1m source-mirror and mirror-focus
- relaxed requirements for debris-mitigation
- homogeneous illumination of sample over ~50 µm "easy" to achieve

Scaling of Brilliance Efficiency

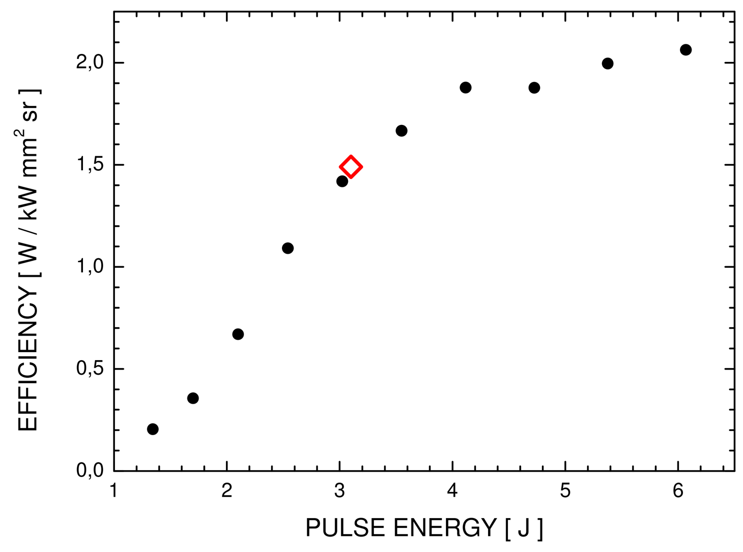


Fig. 6: Energy scaling of brilliance efficiency (red rhomb: old system at 8.7kW)

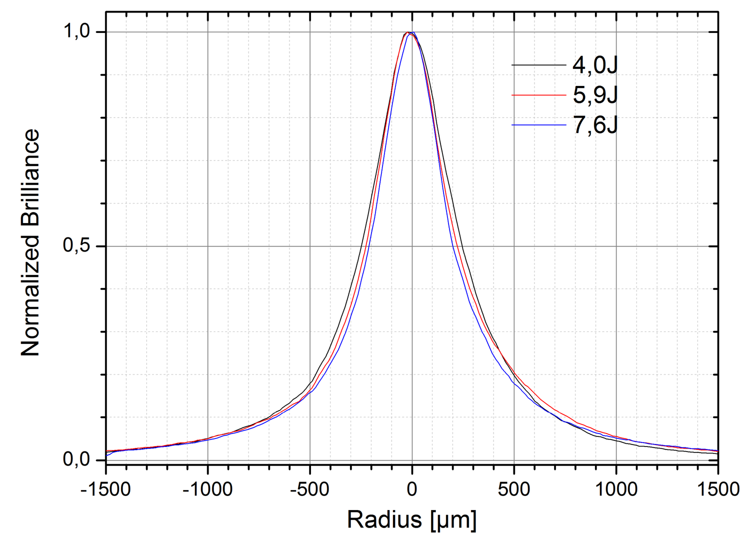
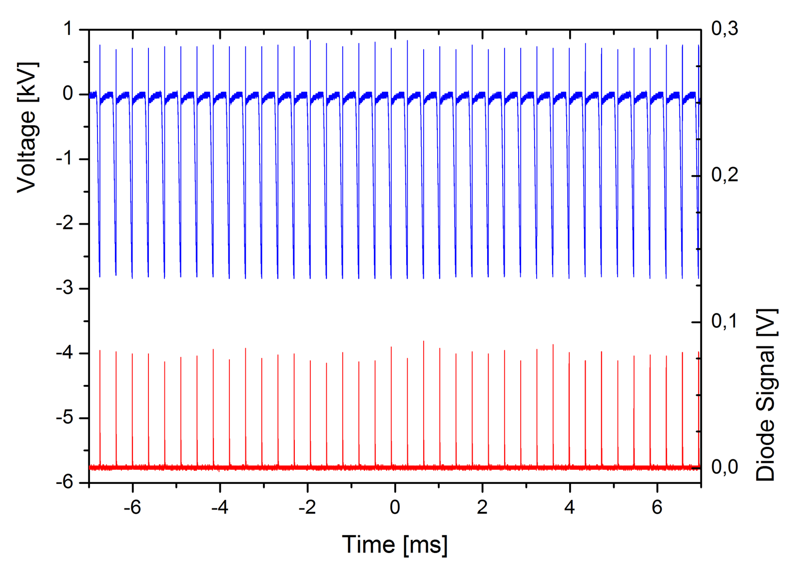


Fig. 7: Brilliance profile is not affected by pulse energy scaling

- demonstration of 2.1 W/(kW mm² sr) at a pulse energy of 6.1 J
- increase of efficiency due to access to higher pulse energies

Demonstration of 26 W/mm²sr



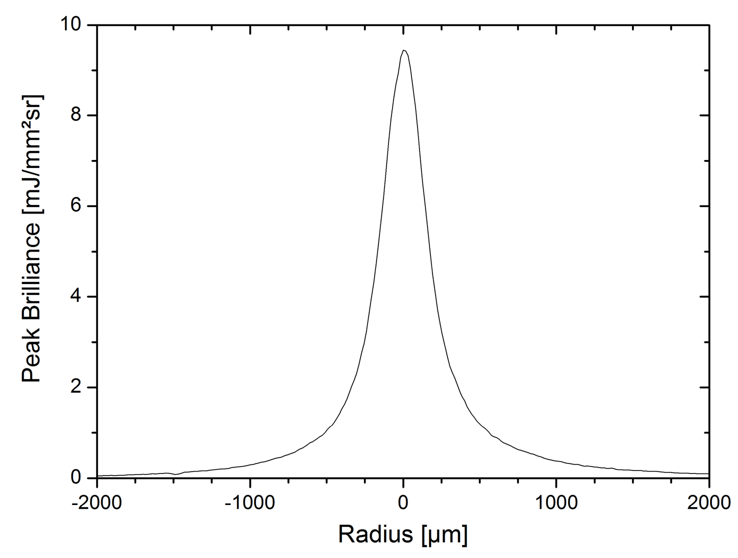


Fig. 8,9: Pulse train at 2.7 kHz and the corresponding emission profile

$$L_{peak} = \frac{f\, E_{in}\, CE}{\zeta\, \pi\, r_{1/2}^2}$$

f	(repetition rate)	: 2.7 kHz
E_{in}	(pulse energy)	: 7.4 J
CE	(conversion eff.)	: 0.4 %/(2πsr 2%bw)
z	(profile factor)	: 4.8
$r_{1/2}$	(radius)	: 180 µm

Scaling Potential to >50 W/mm²sr

- estimation of achievable brilliance by multiplying realistic and already demonstrated best of parameters
- experience with previous system: gas flow conditions are the key optimization parameter

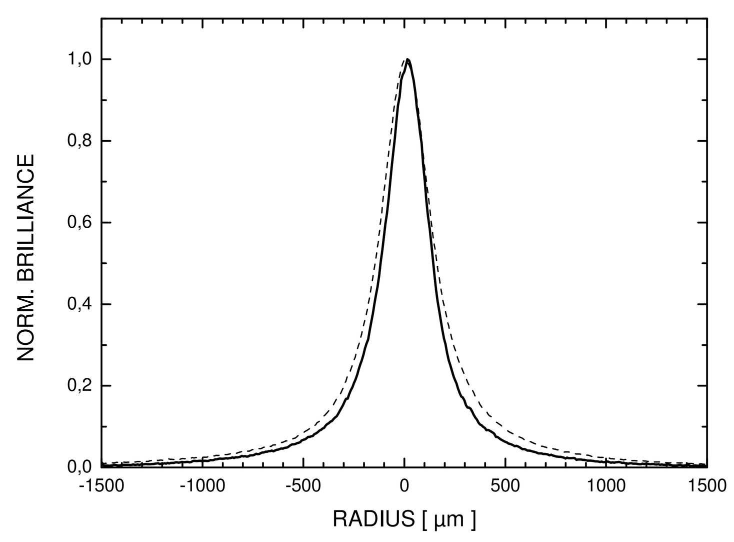


Fig. 10: Source profile with 260 µm diameter (full) and profile from Fig. 9 (dotted)

Best of Parameters

P_{in}=20 kW CE=0.53 %
ζ=4.5 $r_{1/2}$=130 µm

$$L_{peak} \geq 70 \frac{W}{mm^2 sr}$$

Acknowledgements

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